

FY00 Progress Report

Applications of Sunphotometry to Aerosol Extinction and Surface Anisotropy

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A. SCIENTIFIC GOAL

This is a **cost-sharing** research to deploy a newly developed sun-sky-surface photometer for studying aerosol extinction and surface anisotropy at the ARM SGP, TWP, and NSA/AAO CART sites. Atmospheric aerosols affect the heat balance of the Earth, both *directly* by perturbing the incoming/outgoing radiation fields and *indirectly* by influencing the properties/processes of clouds and reactive greenhouse gases. The surface bidirectional reflectance distribution function (BRDF) plays a crucial role in the radiative energy balance, since the BRDF is required to determine (i) the spectral and spectrally-averaged surface albedo, and (ii) the top-of-the-atmosphere (TOA) angular distribution of radiance field. Therefore, the CART sites provide an excellent, albeit unique, opportunity to collect long-term climatic data in characterizing aerosol properties and various types of surface anisotropy.

Under NASA research funds, we are building, in-house, a next generation sun-sky-surface sensor to replace the aged CIMEL sunphotometer. The sensor contains 14 spectral channels, ranging from 0.3 to 2.5 μm with polarization, and is lightweight, low power, and adaptable to most solar trackers. The **deployment costs** in supporting research activities at the CART sites and other major campaigns are covered by the ARM program. Specifically, we will:

- (1) test, refine and operate a newly developed sun-sky-surface sensor at the CART sites, in close collaboration with the ARM-Landsat (or other aircraft/satellite) project, and make data available for ARM community;
- (2) characterize the bidirectional reflectance over arctic tundra, snow and sea ice surfaces, as well as other types of vegetated land surfaces; and
- (3) analyze and retrieve column amounts of aerosol loading and water vapor abundance using sun/sky spectral measurements over the CART sites and compare with results derived from other ARM instruments.

This study should advance our ability in characterizing and parameterizing column atmospheric parameters and surface anisotropy for use in the Single Column or General Circulation Models.

B. ACCOMPLISHMENTS

- Complete and calibrate a prototype sun-sky-surface sensor,
- Prepare for the first field deployment in SAFARI-2000.

C. PROGRESS



Figure 1: A prototype of new sun-sky-surface sensor with CIMEL sunphotometer robot (the background shown a complete CIMEL system).

During FY00 (starting 1 April 2000), we have completed the assembly of the prototype sun-sky-surface sensor (S^3 photometer) and preliminary calibration in the laboratory using lamp source. This new S^3 photometer will provide rapid acquisitions of the directional downwelling and upwelling radiances in contiguous, 1.5° FOV sectors, which cover almost the complete sphere of sky and ground views (only limited by the instrument mount used) in 14 spectral bands from the ultraviolet (UV) through shortwave-infrared (SWIR) wavelengths. Currently, the new instrument uses CIMEL sunphotometer robot (goniometer) and data logger system as the backbone, with modular design of Gatling gun (component replacement in field) sensor head. A prototype of S^3 photometer is shown in Fig. 1. Fourteen spectral bands are centered (bandwidth) at 340 (2), 380 (2), 440 (10), 500 (10), 615 (10), 675 (10), 778 (10), 936

(10), 1030 (10), 1240 (20), 1640 (25), 2130 (50) nm, and 0°/90° polarization at 870 nm. As presently configured, two types of detectors are used: eight silicon (Si) detectors for the visible/near-infrared (up to 936 nm) region and four Indium Gallium Arsenate (InGaAs) detectors for the SWIR region. The ion-assisted deposition interference filters are integrated with detectors on thermal inertia plate (all integrated components replaceable in the laboratory). Due to the necessity of operating at elevated temperature in the field, we have opted for the design that traces its heritage to the GOES sounder detector design. The SWIR channels (1.64 and 2.13 μm) that use the InGaAs detector will have a mounted aplanat lens, which will collect the full FOV flux and focus on a much smaller 40 x 40 μm detector. The smaller detector area will greatly reduce the dark current of the detector at the elevated temperature, while the aplanat lens maintains the flux level and the signal-to-noise ratio. The collimator is designed for 10^{-6} straylight rejection. Detector and ambient temperature will be recorded, and the instrument is expected to operate at all environments including marine and arctic (-50° to +50° C and 5 to 100% relative humidity).

The S³photometer has completed the preliminary calibration in the laboratory using lamp source, as shown in Fig. 2. Running side by side with our reference CIMEL sunphotometer, results of common channels between these two photometers are qualitatively in good agreement. Currently, the radiometric calibration of S³photometer is undergoing tests at the NASA Goddard radiometric calibration laboratory. A well maintained 6-foot (1.8 m) integrating sphere is equipped with twelve 200 Watts quartz halogen-tungsten filament lamps, and is traceable to the National Institute of Standards and Technology (NIST) standard source. The number of lamps illuminating the sphere is varied to produce 12 radiance levels for calibration. Langley plots from NOAA's Mauna Loa Observatory are also planned to be used for determining the spectral extraterrestrial voltage (V_{ol}) for the instruments. In addition, a well-maintained monochromator at NASA Goddard laboratory will be used for spectral calibration. After all these procedures, the S³photometer is set to go for the first field deployment, SAFARI-2000, which will be conducted in South Africa from August to September 2000 for investigating the climatic effect of biomass burning aerosols.

To fully extract aerosol signature (e.g., coarse mode contribution), the SWIR spectral measurements are critical; and to properly capture surface characteristics, fast and adequate sampling of both downwelling and upwelling radiance fields are essential. None of current field instruments meets the above requirements. The most appropriate instrument for long-term aerosol monitoring and surface characterization is the CIMEL-like sunphotometer; however, the current one suffers from: lack of SWIR measurements, using filter wheel, non-modular design, and requiring long sampling time. The successful deployment of S³ photometer will be the first step to overcome these difficulties.

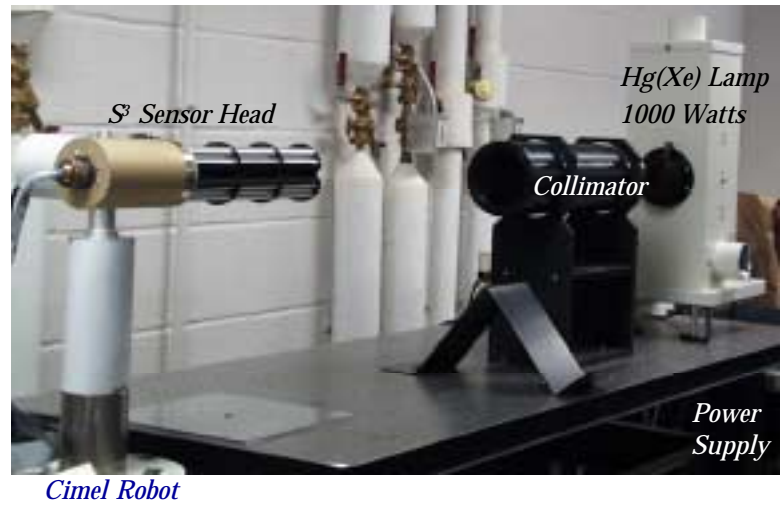


Figure 2: Preliminary calibration of S^3 photometer in the laboratory using lamp source.